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Case study

Human bone ashes found in the Dama de Elche (V–IV century B.C.) reveal its use as an ancient cinerary urn

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ABSTRACT

The Dama de Elche figure is a polychromed stone life-size bust and is recognized as an emblematic piece of Iberian Art (V–IV century B.C.). The Dama de Elche possesses a small cavity in the back whose function has been object of several unconfirmed hypothesis since its discovery in 1897, due to the fact that no apparent indications of its former use could be found. This research has been centered on the analysis of the cavity and the search of data as to be able to confirm its former use. A superficial base-gypsum layer that covered the sculpture had been also detected on the surface of the cavity. Afterwards a recrystallization process took place due to temperature and relative humidity changes. By microscope techniques, several carbonaceous particles have been identified that were immersed inside the recrystallized superficial $CaSO_4.2H_2O$ (gypsum) layer, not visible by visual inspection. The use of the bust as a cinerary urn has been verified with the detection of carbonaceous microparticles in which phosphorus and calcium rich fragments have been identified. The obtained Ca:P ratio indicates their bone origin. The comparison of these analyzed data with other fired remains from human bone samples found in a nearby Iberian archaeological site of the same date holds a very high similarity, which confirms its analogous origin. There are also slag and sinterized particles inside the cavitiy produced at high temperatures. These results are coherent with the cremation funerary rites of Iberian culture that included the setting, even partially, of the ashes inside an urn. The detection of strontium ions, side by side the carbonaceous particles inside the cavity, are related with the thermal process induced at the time of depositing the bone ashes, still hot, from the cremation ritual. In relation to the bust authenticity, these new found data support that the Dama de Elche is a piece of Iberian culture. No data was found to support that it might have been a XIX century forgery.

1. Introduction

Towards the end of XIX century a great interest for Iberian culture in Europe was starting, and rose due to the Dama de Elche discovery. The sculpture was accidentally discovered in August 4, 1897 at the archaeological site of La Alcudia (Elche, South-East Iberian Peninsula). A few days after the discovery, it travelled to the Louvre Museum (Paris, France); in 1941 it came back to Spain, to the Prado Museum (Madrid) and in 1971 was moved to the Archaeological National Museum until today.

The Dama de Elche is recognized as an emblematic piece of Iberian Art. It has been the centerpoint of many studies carried out by a wide variety of scholars [1–11] due to the uniqueness of this Iberian sculpture. The Dama de Elche is a polychromed life-size bust (height: 56 cm) cut out in stone with a hollowed back (Fig. 1).

In a previous study [7], the authors concluded that it was sculpted in fossiliferous limestone of Miocene (Tertiary Age). Two classic pigments being identified: Egyptian blue (calcium-copper silicate) with a flux (potassium carbonate) and natural vermillion (mercury sulphide); applied over a preparation layer on the surface, identified mainly as $CaSO_4.2H_2O$ (gypsum) mixed with calcium carbonate. At the time of the discovery, drastic changes in the environmental conditions of the bust were produced as it was moved from the burial, completely cover with soil to the summer season high temperatures. There was a rise in temperature and a reduction of relative humidity, which caused the drying of the bust, provoking the transport of the moisture from the inside to the outside of the bust. In this process, part of the base-gypsum layer applied as primer was dissolved and later precipitated, hiding the pigments inside. These wet/dry processes of the bust and

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Fig. 1. Dama de Elche – View of the back cavity.

dissolution/recrystallization on the external surface of the base-gypsum were repeated until the sculpture dries.

One the most debated aspects of the sculpture is its chronology. As the discovery was fortuitous, archaeological data were not obtained at that moment. Several studies provide datation from different experts that support their affirmations on technical, historical and stylistical criteria [5,10]. Its Greek influence is enhanced and the historical context and its location are analyzed. Fundamental analysis locate it on the Iberian sculpture period [5]. Abundant suggestions point out the date of the bust around the V century B.C. [3,5] and the IV century B.C., although there are also opinions of a more recent date [6]. The archaeological excavations carried out at La Alcudia site have allowed to establish the different archaeological strata and their chronology, as well as the possible association of the bust with the historical complex of the Iberian temple discovered there [10]. The systematic works carried out by Alejandro Ramos (1949–1950) established an archaeological level of a time before the city's destruction, and was formed by abundant fragments of Iberian sculptures. With this finding the datation would be settled from the end of the V century B.C. to the IV century B.C. [10] and allows the association of the bust with the Classic Iberian period [10,11].

The back side of the Dama de Elche has a roughly asymmetric sculpted ovoid-shaped cavity (width: 18 cm; depth: 16 cm) [6] with no visible signs nor remains regarding its purpose or use in the past, from the moment of its discovery [5,12,13]. Since the time the sculpture was discovered in 1897, the bust has given rise to several interpretations over its identity (lady or goddess) [10,14] and the meaning and function of the ovoid cavity. P. Ibarra in 1897 [13] related the cavity as a resonance box for pronouncing oracles; others thought it as an anchor zone so as to raise the sculpture [6,13] or a shrine/deposit for offerings [10,13]. Thus, the function of the cavity was then unknown [5,15]. Based on the analogies of other Iberian pieces found after the discovery in 1971 of the Dama de Baza [1] which shows funerary dimension [1,9], some authors suggested it may have served as a cinerary urn [3]. Although, while in the case of Dama de Baza the cavity for the bones was large (~9000 cm^3). Yet in Dama de Elche it is very small, and does not allow an analogous deposit [13]. Years before, the cavity of the bust was thought to be used for other purposes [3,10].

Nowadays there are many opinions about the possibility of depositing ashes and other remains of a corpse cremation [5] but there is not any documentation that could verify it. It remains however an unresolved issue [4] since rigorous scientific studies, regarding the cavity and possible remains inside it, were still to be carried out. Recent sources indicate that the cavity shows no signs of having been used for funerary purposes or as a cinerary recipient, nor is there any blackening observed in the cavity [12]. On the other hand, it should be pointed out that no intervention has been done to the sculpture since it was excavated.

A possible Egyptian influence via the Mediterranean Sea and due to the Phoenicians has also been suggested based on the archaeological finding of an Egyptian-style beetle in La Alcudia which could relate the Egyptian back cavities to the Iberian ones [13].

The Iberian world expressed its religiosity through its funerary rites and proceeded to the incineration of the dead with the gathering of the ashes and the rests of the cremation, placing them into an urn [16], that was then placed in the final burial place [4,17]. In the South-East of the Iberian Peninsula tombs from Iberian necropolis have been excavated, leading the researches to be able to affirm that they are sure of having acquired the knowledge of the funeral rite of the Iberian world; due to the extensive amount of tombs studied in this peninsular zone [18]. The Iberian world proceeded to the cremation due to their religious beliefs in the after world, as a purification rite of the dead, transformed by fire. It was carried out to all the population except to the babies [4]. Documental sources reveal that the cremation of the dead was made in a funerary pyre of lumber. The cremation residues were ritually taken out while still hot [17] and placed in a recipient or urn that was usually placed with the trousseau inside the tomb. It can be verified, due to residues and marks on the trousseau objects, that they were also taken as incandescent embers and deposited in the urn. On occasions, just a part of the corpse (skull. . .), depending on the size of the urn. The rest were placed directly into the tomb. Because of this other objects got burn marks, as the embers got in contact with them [18].

The identification of remains indicating the use of Dama de Elche as a cinerary urn is relevant to the debate over its authenticity, as it would indicate a coherent use with its attributed historical period. This would in turn dismiss the XIX century forgery hypotheses due to the fact that this kind of use was not known at the time of the discovery, nor any other Iberian sculpture had been found with a similar cavity.

The study of the Dama de Elche is of great relevance from a cultural point of view due to the obtained conclusions, both from previous study and the ones presented here, that also ratify that the sculpture is not a modern falsification [7].

The present study focuses on the cavity of the back of the sculpture, in its constituent materials and the search of some indication of its former use and states its first scientific research; with the initial hypothesis that it was used as a cinerary urn.

2. Analytical procedures

Several microsamples were extracted from the interior of the back cavity of the bust of Dama de Elche. The research is based on electronic microscopy technique with a prior study and selection of samples by optic microscope (Leica, model MZFLIII) which allowed to exclusively work with microsamples. For the study by Scanning Electron Microscopy (SEM), part of the samples where metalized with Au to be able to detect carbonaceous particles. Others metalized with carbon to analyze, in a second phase, these particles in order to detect P and other elements that could be overlapped by Au spectral lines. With SEM/BSEI using density contrast imaging (Back-Scattering), particles with P or Sr were detected. A multipuntual analysis with a prior Z mapping element distribution was also made. The analysis by SEM include: Secondary Emission Imaging (SEI) and Back-Scattered Electron Imaging (BSEI), Qualitative and Quantitative Microanalysis by X-Ray Energy-Dispersive Spectrometry (XEDS) with ZAF correction and reference patterns at 20 keV.

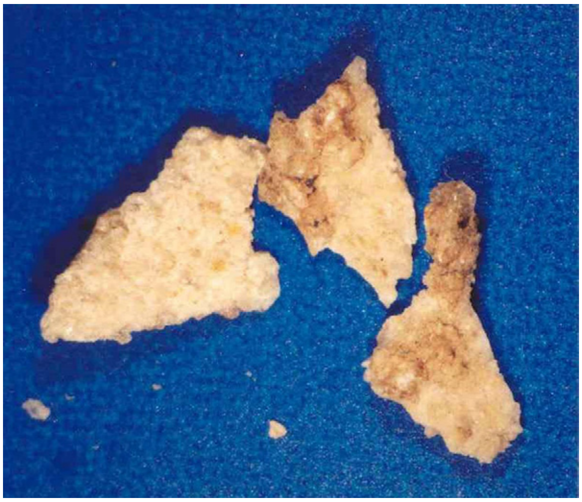

Fig. 2. Samples from the cavity (optical microscope at ×10.7). On the right: carbonaceous-like particles with porous texture and black colour are detected in the shiny superficial layer of recrystallized gypsum. On the left: reverse of a similar sample with carbonaceous particles on the surface.

A JEOL-6300–SEM equipped with an energy-dispersive spectrometer XEDS Link Isis-300 with 138 eV resolution (boron-uranium) was used.

3. Results and discussion

3.1. The processes inside the cavity and detection of the carbonaceous particles

A preliminary analysis by optic microscopy of several samples of the cavity (hypothetic cinerary urn) was made and black isolated particles with carbonaceous appearance, not visible to the naked eye, were detected (Fig. 2). These particles were immersed inside a recrystallized superficial $CaSO_4.2H_2O$ (gypsum) layer with mamelonar morphology (Figs. 3, 4 and 5). This layer forms a superficial coating throughout the entire sculpture and is also found inside the cavity (Fig. 4a). This was described in a previous paper about the polychromed surface of the bust [7]. This identified layer constitutes a very hard superficial coating which impairs the study of the layer and the carbonaceous particles within (suspected ash). The carbonaceous particles are only located in the superficial zone of this coating and not in the inner parts (Figs. 2 and 5).

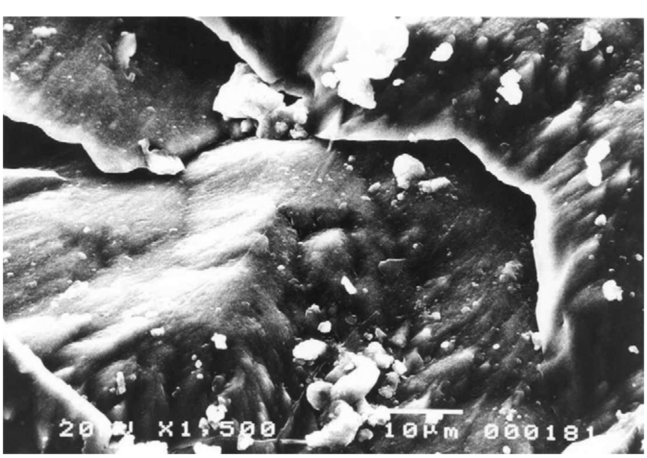

Fig. 3. SEM image of the recrystallized gypsum on the surface of the cavity where carbonaceous particles are immersed.

This result is consistent with the funerary rites of Iberian culture which usually consisted of the cremation of the body [16] and the gathering of the ashes to be kept in their final place: a tomb or an urn [4]. The urns could contain only partial remains from the incineration, depositing the rest in the tomb beside the trousseau [18]. The ashes were possibly introduced inside the cavity while they were still hot, due to its surface morphology. This hypothesis is supported with bibliographical data which refer to the deposition of incandescent embers [17,18]. This would have favoured their incrustation in the layer of gypsum as it produced phenomena such as redissolution and precipitation in the base-gypsum layer (Fig. 4b). Also, processes of transport and recrystallization of the superficial base-gypsum layer, due to temperature and humidity changes, suffered by the bust after its excavation, were produced [7] (Figs. 2, 3 and 4c).

3.2. Analysis of the carbonaceous particles

Using Back-Scattered Electron Imaging (BSEI), distinct contrasts of grey shades were observed, corresponding to zones with different density and composition (Fig. 5):

- clear and bright zones of smooth and uniform texture. These zones are denser than the zones containing carbonaceous particles. They constitute the recrystallized superficial layer and mainly consist of $CaSO_4.2H_2O$ (gypsum);
- darker grey zones of granulated texture and lower density; due to the presence of carbonaceous particles. They contain small particles of calcium and phosphorus, somewhat denser but hardly perceptible by optic microscope as they have a diameter of a few microns;
- slightly denser and bright particles have also been observed, constituted by strontium and sulphur.

Particles containing phosphorus are found in all cases, in the superficial layer of the recrystallized $CaSO_4.2H_2O$ (gypsum). By their morphology and composition, three types of particles containing phosphorus can be differentiated (I, II and III) (Fig. 6a, b and c):

- pseudo-spherical particles (3 μm approx.) (I) with calcium as main element and very little phosphorus (2–3%) (Fig. 6a and b);
- aggregates of sharp-cornered fragments (1–2 μm) (IIa, IIb, IIc) (Fig. 6a and b) (Table 1), made up mainly of phosphorus (23-31%) and calcium with Ca/P ratio: 2.1, 1.8 and 1.5, but also containing silicon, sodium, magnesium, aluminium, potassium, sulphur and chlorine (Fig. 6a and c). The results of microanalysis (XEDS-SEM) and the Ca/P ratio indicate an osseous origin;
- aggregates of microparticles (less than 1 μm) (III) containing varying degrees of phosphorus, unquantifiable due to their small size.

The origin of these phosphorus-containing particles, detected in the ashes of the cavity, can be attributed to the cremation of bones. Their sizes correspond to calcination ashes. They are incrusted in the upper, superficial zone of the recrystallized $CaSO_4.2H_2O$ (gypsum), not in inner zones, which exclude them from being impurities in the gypsum. These particles cannot be related to remains of ceramic materials with phosphated additives of organic origin, due to the fact that their chemical composition contain a higher percentage of Fe and their morphology and intraparticle structure are clearly different to the those observed [19].

These particles present differences in composition and morphology which indicate that they correspond to two parallel or simultaneous processes that occurred during cremation: (a) the

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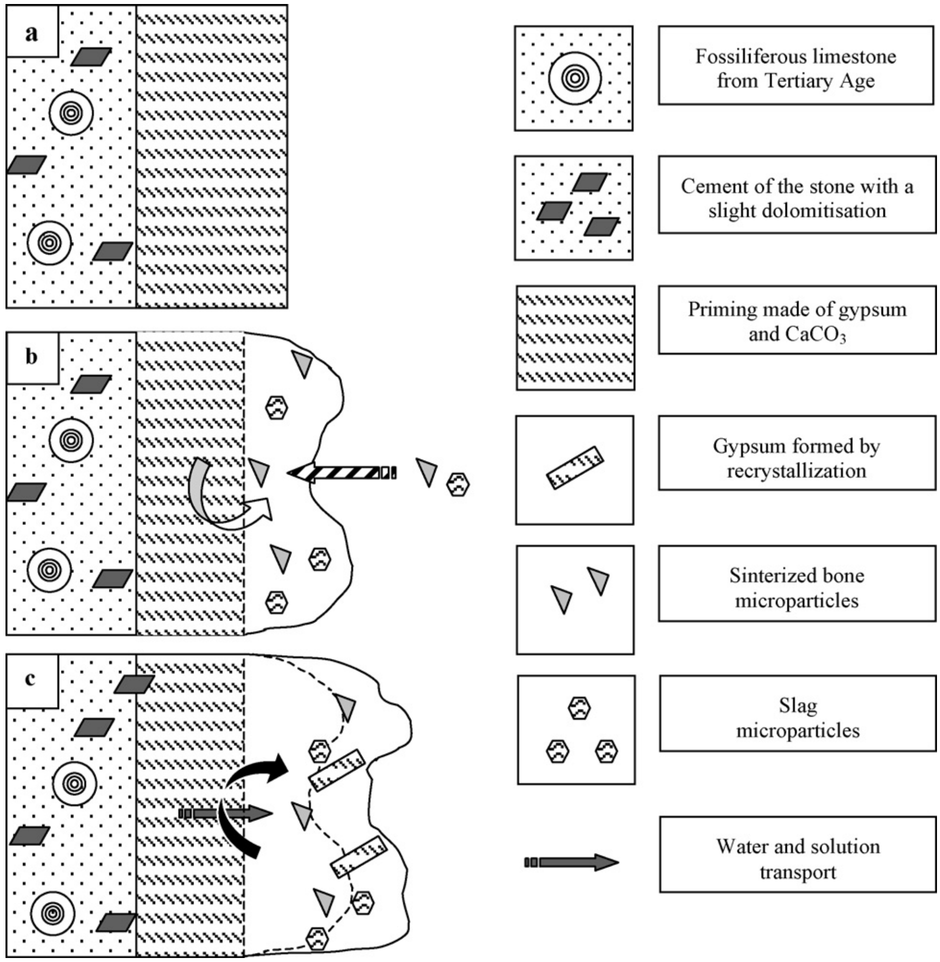

Fig. 4. The processes inside the cavity of the bust: a: stone of the sculpture and priming layer; b: the bone ashes are placed inside the cavity; c: processes of water and solution transport and recrystallization of the superficial layer.

formation of remains of a mixed nature of: bone, ash and earth; and (b) the calcination of bones and teeth.

The first type (I) of pseudo-spherical particles (Fig. 6a and b), that have a greater proportion of silicon, can be considered a heterogeneous mixture of earth and slag type vitrified bone remains, as described in several remains of funerary pyres [20]. They would correspond to the first process of formation (a) occurring during cremation.

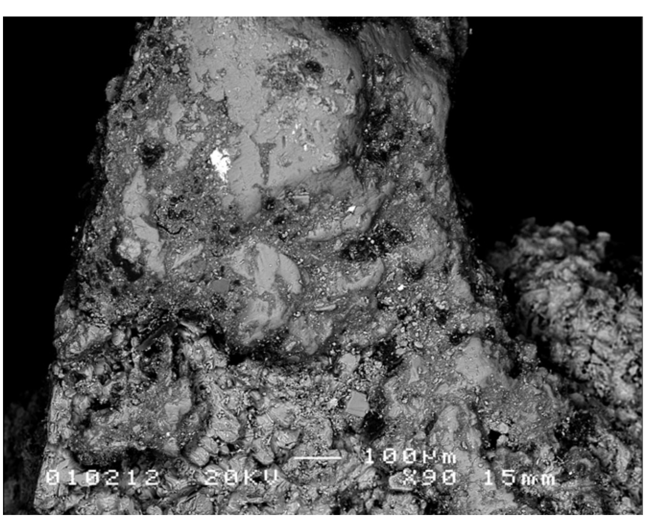

Fig. 5. Bone-ash particles from the cavity: SEM-BSEI micrograph of a zone of the cavity containing different phosphorous and strontium particles in the surface layer of the recrystallized $CaSO_4.2H_2O$ (gypsum).

The second type (II) of particles, more angular in shape and rich in phosphorus (Fig. 6a and b) is similar in composition to sinterized slag [20,21] found in several archaeological sites coming from funerary pyres or human bone remains calcined in a process of cremation; or vitrification produced at temperatures above 1000 °C. At such high temperatures, the organic material, and specially that of a keratin nature, coming from nails and hair, together with other alkaline elements that act together as fluxes, reach sinterization [21].

This hypothesis regarding the origin of these splintery particles, rich in phosphorus (II), as remains of sinterized bones and teeth, originated in the process of formation during cremation, is based mainly on three aspects:

- the calcium-phosphorus ratios obtained from the microparticles of the cavity (Table 1) have a value of 2.1, or near this value, indicative of their bone origin. The theoretical reference value of the Ca/P ratio in human populations is ~ 2.16 with variations due to the time of the bone or the person's age, among others [22,23].

  Several paleontological studies of human remains on various archaeological sites obtained similar analytical data to the ones in this research [23,24].

  Recent studies [24] on late Roman populations from the coastal South-Eastern Iberian Peninsula suggest significant diagenesis;

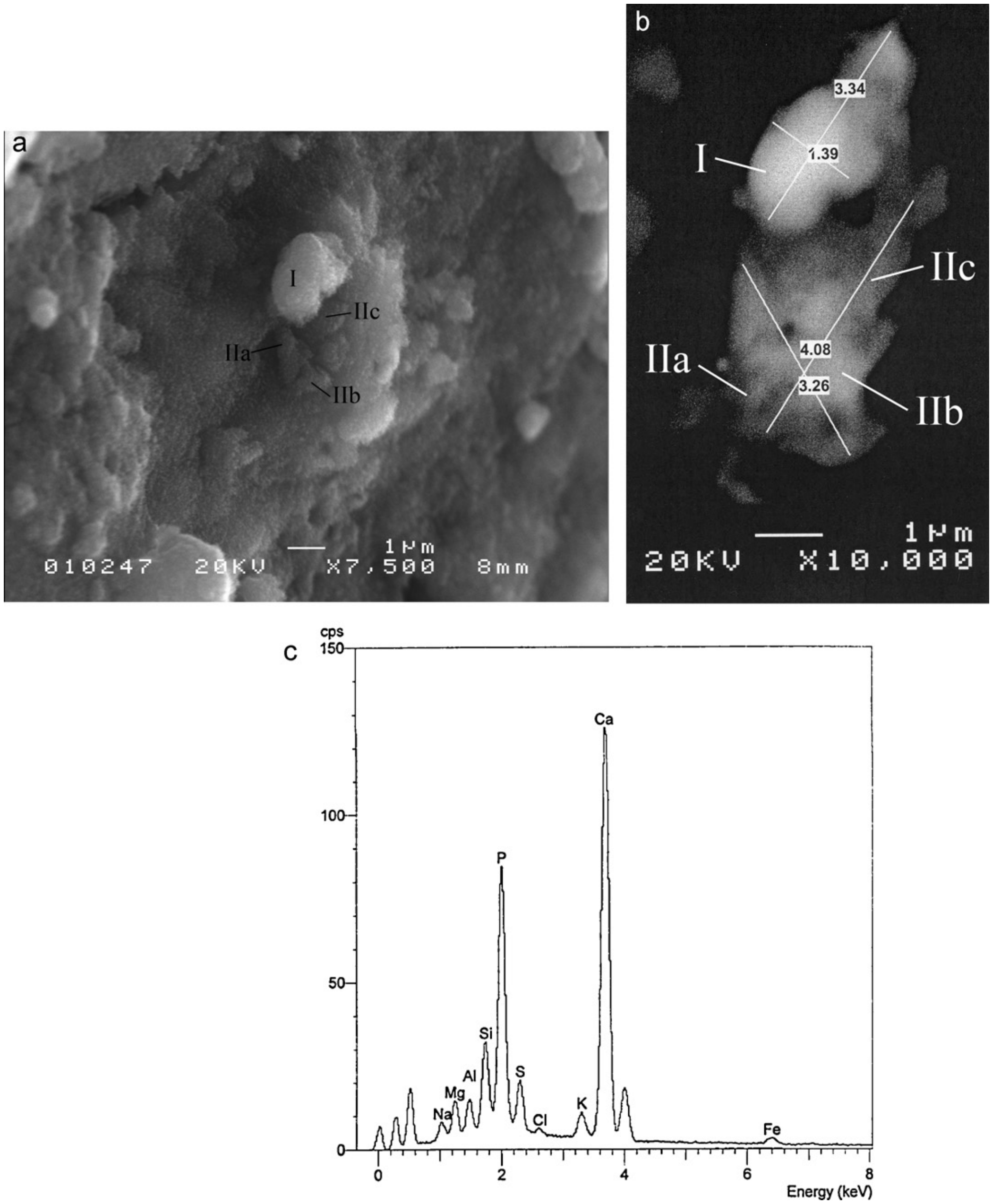

Fig. 6. a: different types of particles from bone cremation with phosphorous content, immersed inside a recrystallized superficial layer of $CaSO_4.2H_2O$ (gypsum): pseudo-spherical particles (I) and aggregates of sharp-cornered fragments (IIa, IIb and IIc); b: the size of the slag particles (I, and II); c: the XEDS spectra of samples (IIa) from the cavity are very similar to those of sinterized bones [21].

and present Ca/P ratio values fluctuating from 1.80 to 2.30 and even 2.50. These high values have been justified as post-mortem changes in the bone composition;

- the XEDS spectra of samples from the cavity are very similar to those of sinterized bone slag, taking into account the relative intensity of their peaks and the presence of silicon and alkaline elements (Fig. 6c) [21];
- the comparative analysis vs. incinerated human bone remains found in funerary ceramic urns from a nearby Iberian archaeological site from a similar period (V–IV century B.C.) and located at coastal South-Eastern Iberian Peninsula near the discovery site of the Dama, present similarities on their composition and their calcium-phosphorus ratio (Table 1). Nevertheless they also show differences:
    - in some of the fired samples from the Iberian archaeological site, a sharp decrease in phosphorus content is observed, related with a proportional increase of silicon,
    - the composition of the human bone remains of the archaeological site is not homogeneous and there are zones with varying degrees of silicification. This silicification, depending on the temperature reached, can be originated during the process of cremation. The existing variability in the degree of silicification can also be due to a diagenesis process that bones can undergo in contact with the burial soil [20,21].

These processes of silicification do not sufficiently explain the differences observed between the human bone remains of the archaeological site and the microparticles found in the

Table 1
The carbonaceous particles of the Dama's cavity have a high phosphorous (P wt%) and calcium (Ca wt%) content with variable proportions of silicon (Si wt%) (Fig. 6a and b) in comparison with fired human bone ashes from a nearby Iberian archaeological site (F HBA).

Type of sample	Source	P	Ca	Si	Ca/P ratio
Carbonaceous particles inside Dama de Elche	Cavity (IIa)	23.1	50.6	6.5	2.1
	Cavity (IIb)	29.4	52.1	1.9	1.8
	Cavity (IIc)	30.8	46.0	4.2	1.5
Iberian fired human bone ashes	F HBA	28.1	62.2	4.2	2.2
	F HBA	16.4	38.4	25.6	2.3

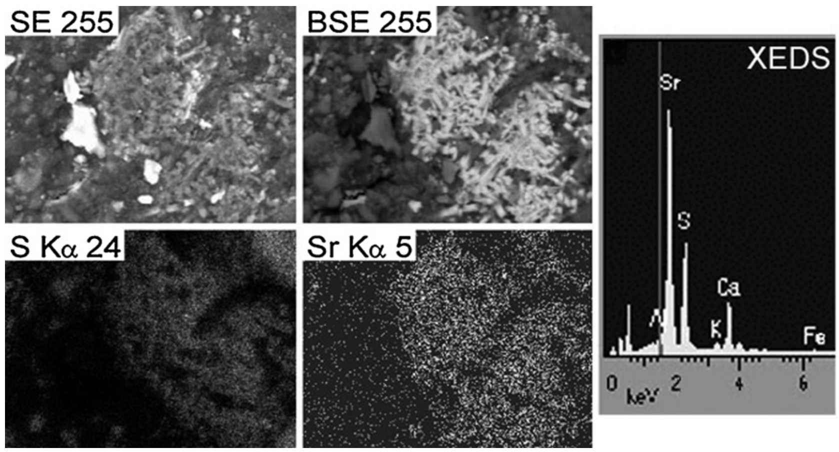

Fig. 7. Strontium (Sr) migration: microcrystals of strontium sulphate ($SrSO_4$) superficially incrusted in the mass of recrystallized gypsum (X-ray image). XEDS of microcrystalline aggregates containing strontium and sulphur (celestine).

cavity, because the studied carbonaceous microparticles contain a higher degree of phosphorus and a slightly lower Ca/P ratio. These obtained ratios are lower than 2.16, value established as theoretical reference [25] (Table 1). However, there are references on human bone samples for nearby populations (La Molineta necropolis) with Ca/P values of 1.80 (low ratio) [24], similar to the obtained in this research (Table 1).

These differences may be due to various kinds of processes. Among them, the possibility of chemicals alterations being produced could be considered [24].

Regarding the pyrolithic process under high temperature, transformations were produced that generated minerals, richer in phosphorus, with a different composition and structure.

The mineral composition of the particles could not be determined due to their small size. This would be a hydroxylapatite composition similar to the observed in remains of dental enamel [26].

On the other hand at temperatures higher than 800 °C, bones turn into β-tricalcium phosphate [21], a mineral richer in phosphorus, and one that, according to other authors, is often accompanied by complex phosphorus, calcium and iron minerals. These last characteristics relate more closely, both qualitatively and quantitatively, with the XEDS spectra obtained from the particles of the cavity.

This interpretation of the mineral composition of the phosphatized particles of the cavity confirms the process of sinterization and reinforces the idea of the origin of these particles as bone remains resulting from incineration.

3.3. Detection of strontium

Acicular microcrystals of strontium and sulphur aggregates have been detected inside of the recrystallized layer of gypsum on the cavity (Fig. 7) and identified as strontium sulphate (celestine). The strontium appears side by side to the ash particles, but not within the applied base-gypsum superficial layer or the recrystallized $CaSO_4.2H_2O$ (gypsum).

This compound could be explained by the migration of strontium ions to the wall of the cavity due to a thermal process induced by the placing of the still hot ashes into the cavity, according to the funerary rites [17,18,27,28].

The Sr ions can hypothetically come from the cremated bone ashes or by a neoformation process of celestine due to the transformation of anhydrite into secondary gypsum [29].

The strontium became lodged inside the gypsum layer because of its heaviness, not a very volatile element and was absorbed in the gypsum coating that covers the cavity.

4. Conclusions

The studies carried out on the materials found in the cavity of the back of the Dama de Elche have allowed to reach the following conclusions:

- a layer of recrystallized $CaSO_4.2H_2O$ (gypsum) that covers the interior of the cavity has been detected. It has mamelonar morphology due to the impact of the thermal processes (Figs. 2, 3 and 5).

  This indicates that the base-gypsum primer, used as a base for the polychromy [7] and that covers the surface of the bust, was also applied to the surface of the cavity;
- carbonaceous particles have been found and identified inside the superficial layer of recrystallized $CaSO_4.2H_2O$ (gypsum) (Figs. 2, 4 and 5). These particles have been preserved due to the processes of dissolution and recrystallization of the gypsum superficial layer. On crystallizing, the gypsum retained the carbonaceous particles caught in it. This phenomenon may have occurred after cremation, due to the insertion of the ashes while

still hot in the cavity, following the described Iberian funerary rites [17,18], as well as, with the changes of temperature and humidity that the sculpture has undergone since it was unburied [7];

- the origin of the carbonaceous particles found has been attributed to the cremation of bones. The Ca/P ratio value of 2.1, or near this value, indicate these microparticles to be of bone origin;
- they cannot be related to phosphated additives of ceramic materials;
- a comparison of the obtained analysis with the carbonaceous particles from the Dama's cavity and the human bone remains that also had an incineration ritual, from a nearby Iberian archaeological site of the same date, show similitude; which supports that ashes from incineration of human bones were deposited in the cavity. The differences found in the proportions of P, Ca and Si between both cases are due to the different processes that were developed during cremation.

  The historical context of this sculpture and the nowadays knowledge of the funeral rituals of this Iberian epoch are strong arguments to the consideration of the incinerated remains found in the Dama's cavity being of the human origin.

  The shallow capacity of the cavity points out to think that only some of the incinerated remains were introduced in the cavity, as it was the custom to do [18].

  There are two parallel or simultaneous processes that occur during cremation: (a) the formation of remains of a mixed nature of bone ash, earth and slag type, (b) and the calcinations of bones and teeth by sinterization. The particles found in the interior of the cavity correspond to both types (Fig. 6a and b, type I and II).

  The proportions of P, Ca and Si, as well as their XEDS spectra indicate that some of the splintery particles of the cavity come from the process of sinterization of bone and teeth occurring in a cremation rite;
- the microcrystals of strontium sulphate (celestine) appear in places very near the ash particles. This compound could be explained by the migration of strontium ions, due to a thermal process induced by placing of the still hot ashes into the cavity, according to the funerary rites [17,18].

Following the analysis of the back cavity of the Dama de Elche, in which carbonaceous particles were detected and identified, the function of the cavity of the sculpture as a cinerary urn can be verified. These results are consistent with the funerary rites of the ancient Iberians. They generally consisted in the cremation of dead people [4] as a purification ritual, the gathering of the ashes, and occasionally, the incandescent embers [17,18], which were usually placed in an urn [4,16], even partially [18]. This could be the case of the Dama de Elche due to the reduced capacity of the cavity.

Its funerary use as a deposit for ashes, together with the result of previous studies [7], allows to conclude that the Iberian sculpture of Dama de Elche is not an anachronism, neither as far as the settled dating nor its function is concerned. In the analysis of the bust no indication was found which might allow to suspect that the Dama de Elche is a XIX century forgery.

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